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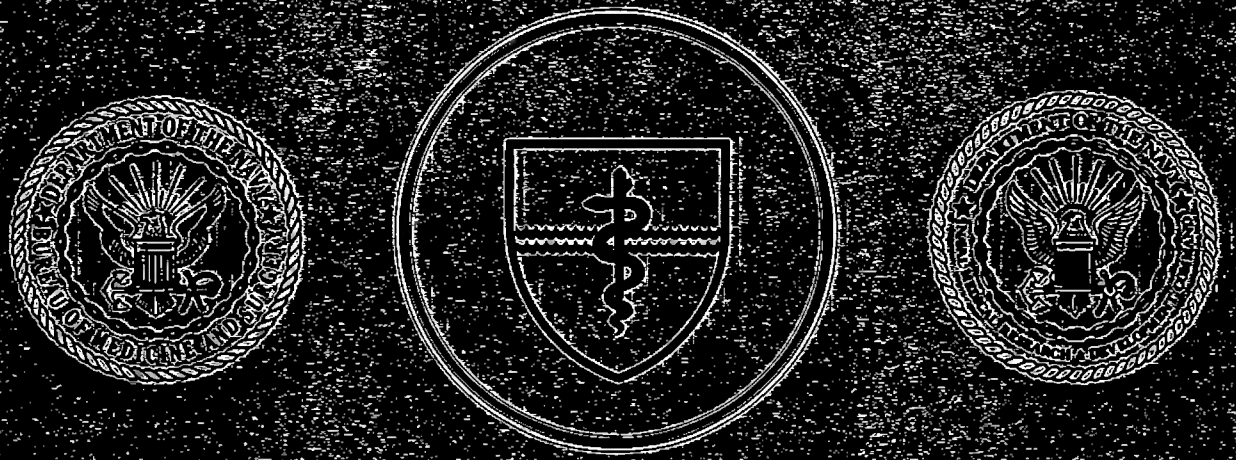

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and
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Naval Medical Research and Development Command
Research Work Unit M0100.001-1021

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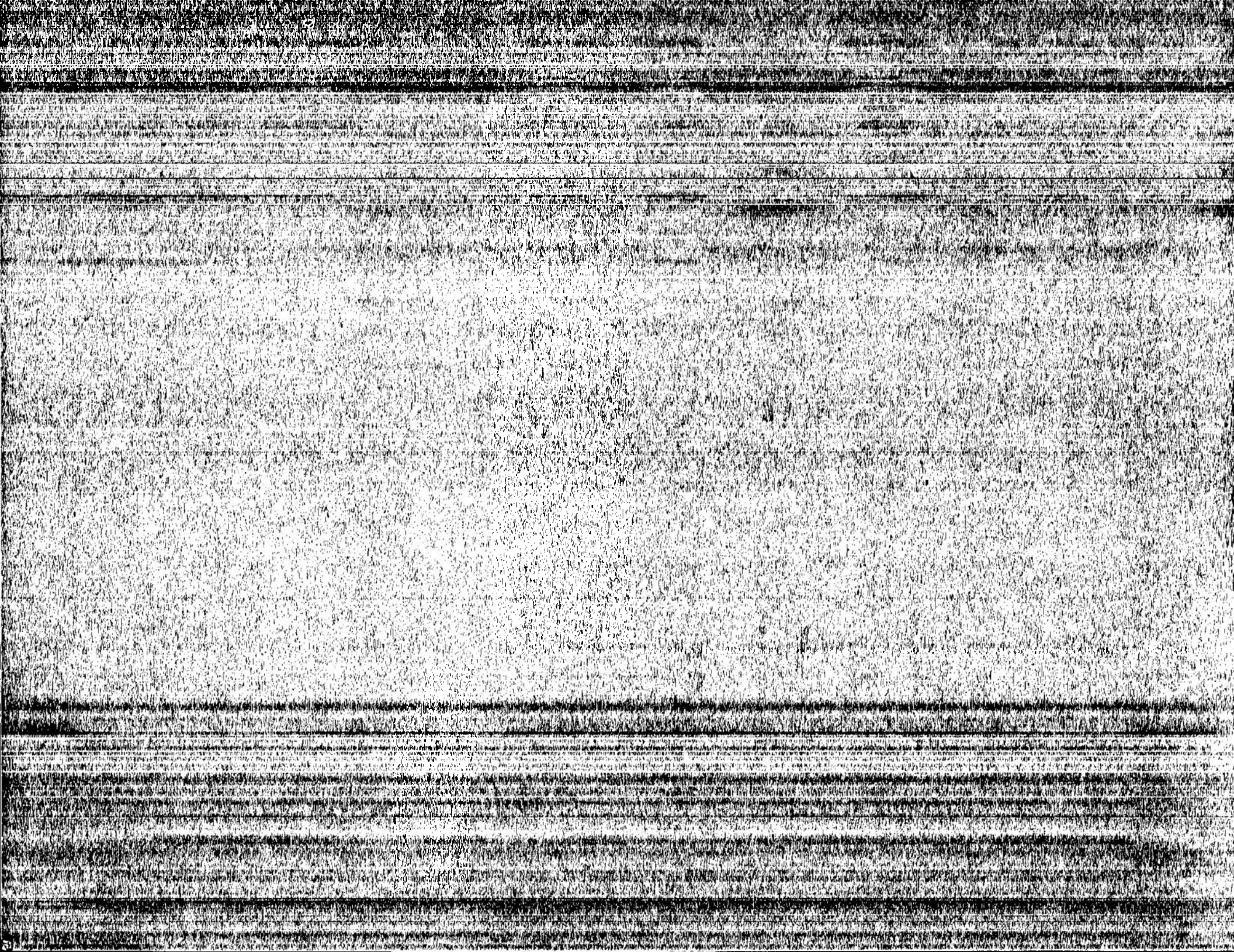

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Research Work Unit M0100.001-1021

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SUMMARY PAGE

PROBLEM

Sonarmen are constantly confronted with information presented simultaneously through different sensory modalities. Verbal information is one type of input to which they are exposed . Little is known regarding the effect of undirected attention when verbal information is presented simultaneously to the auditory and visual modality. The question of interest is how do unimodal and multimodal presentation conditions differentially affect performance?

FINDINGS

The superiority of any particular modality depends upon the task requirements, response demands and the complexity of the stimuli. Multimodal stimulation facilitates the RT of the slower unimodal presentation while providing little if any facilitation to the faster unimodal approach.

APPLICATION

Sonarmen are exposed to various types of information. Reports of this study and previous studies have shown that the results are task dependent. Therefore, it is important to determine how different types of stimuli interact with modes of presentation and affect sonar performance.

ADMINISTRATIVE INFORMATION

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ABSTRACT

The effects of presenting words either visually, aurally, or in both modalities at once on simple and choice reaction time were examined when the words were either related or unreleated to a given category. Simple RT was faster than choice RT, and RT to related words was faster than to unrelated words. Presenting words visually and aurally at the same time did not improve simple RT, but it did improve choice RT when the same word appeared in both modalities. Words that were not identical and not related to a given category in the bimodal condition produced the longest reaction times. It appeared that the simultaneous presentation of meaningful information in two modalities is beneficial only when the information is rendundant.

A great deal of research has been devoted to the study of the processing of stimuli presented to one sensory modality.single modality. Less attention has been given to ways in which different senses interact, although we are constantly confronted with information presented simultaneously through several sensory modalities. Changes in sensitivity or temporal response to a given stimulus when it is accompanied by a stimulus in another modality have been often reported (1-5). In these studies one stimulus acts as an accessory or priming stimulus with its onset just prior to, or simultaneous with, a target stimulus. For example, reaction time improves when an auditory stimulus is presented simultaneously with, or in close temporal proximity to, a visual stimulus (6-8). This has been referred to as bisensory facilitation.

Two models have been proposed to explain the facilitation effect of simultaneous stimulus presentation (9). The "energy summation" model proposes that stimulus energies of the primary and accessory stimuli are combined in such a way that the total energy of the stimuli is equivalent to that of increasing the intensity of the primary stimulus alone. The "preparation enhancement" model suggests that the accessory stimulus functions as an alerting cue (9). Both of these models are based largely on studies which have employed simple stimuli such as lights and tones, but have failed to address the issue of multimodal processing of meaningful information.

Loveless, Brebner and Hamilton (10) reviewed a number of studies in which two signals were presented both of which conveyed relevant information concerning a task. They suggested that bimodal presentation of information facilitates performance when the stimuli are functionally related. Another important finding was that subjects can divide their attention between two modalities without a decrement in response to either modality alone (10-11).

There seems to be growing evidence that individuals can process two or more meaningful messages presented simultaneously in the visual and auditory modalities. For example, Lewis (12) as well as Sen and Posner (13) found improved reaction time for attended words in either modality when the same word was presented simultaneously to the unattended modality. Investigators have been concerneZd with determining conditions under which facilitation or inhibition occur. Hanson (14) found facilitation when words in the visual and auditory modalities were semantically related and/or redundant; however, in her study attention was directed to one modality at a time.

Submarine sonarmen receive a great diversity of meaningful information both visually and aurally. Yet, little research has investigated how multimodal processing affects detection and classification of meaningful signals in one or both modalities. One such study, which used actual auditory signals but a simulated visual display (15) reported that a combined presentation was generally better for sonar performance. However, in a more recent sonar detection and classification study, in which actual sonar displays were used for both modalities, bimodal performance was not

different from unimodal performance (16).

Sonarmen are exposed to various types of meaningful information such as acoustic displays, alarms, and words. The operators receive large amounts of visual information such as text on graphic screens which provide input about a contact of interest. Additionally, conversations are almost constantly carried out between operators, the sonar supervisor, and the officer of the deck in the control room. Sonarmen attend to multiple types and modes of information at the same time and make decisions and responses based on this information. Yet, little is known about the effects of various types of multimodal information on sonar performance.

The present study tested the effects on simple and choice RT of visual and auditory words presented alone or simultaneiously with attention undirected. We were particularly interested in exploring the effects of same and different words in each modality, and the effects of related or unrelated words to a given category. The major question was under what conditions do facilitation or interference occur?

Method

Subjects

Subjects were 20 male university students who volunteered for the study. Their ages ranged from 17 to 28 years, with a mean age of 21.6 years. All subjects had normal hearing, normal or corrected-to-normal vision, and no obvious motor deficits.

Apparatus

Visual and auditory presentation of words was controlled by an Apple II Plus computer and a Votrax voice synthesizer. Synchronization of the onset of words in the simultaneous visual and auditory conditions and data collection were controlled by the Apple II Plus computer. Headphones (Pioneer SE-500) were used for the auditory presentation of words.

The subjects sat in a chair approximately 100 cm. from the computer screen. They listened to words at a comfortable listening intensity (60 dB) through a set of headphones. Subjects responsed on a Koala Touch Pad. The pad was designed with a home button and one or two buttons for the simple and choice reaction time tasks respectively.

Procedure

There were two parts of this study. In part one, simple reaction time was measured when subjects removed their finger from a home button and pressed a response button as soon as they saw or heard a word. There were three conditions: a) visual presentation of words; b) auditory presentation of words; and c) simultaneous visual and auditory presentation of words. Reaction time was measured from word onset. The entire experiment was under computer control. The computer informed the subject at the beginning of each block of trials whether they would see or hear the words or both. They

were told to place their hand on the home button of the Koala pad and as soon as they saw or heard a word, they were to press the "yes" button as fast as they could and then return their hand to the home button. They were reminded not to remove their hand from the home button until they saw or heard a word. If a subject's hand moved before the words were presented the trial was not run. This occurred on the average of once per subject.

In part two of the study, subjects again were presented with words in the visual, auditory, and simultaneous conditions. However, choice reaction time was assessed as they decided if the word or words presented were semantically related to a given category. The computer informed the subjects of the type of category (for example, "numbers"). When the word was presented, they were to decide if it belonged to that category. They were to press "yes" if it did, and the "no" button if it did not. During the simultaneous condition the two words were either the same (identical) or different. If one or both of the words belonged to the category, they were to push the button marked "yes." If neither belonged to the category, they pressed the "no" button. For example, if the category was "numbers" and they heard "dog" and saw "two", they would press the "yes" button.

Subjects were given 15 practice trials, five trials of each of the three conditions, prior to each part of the study. In each condition of parts one and two of the study, words were grouped into blocks, each containing one additional practice trial and eight test trials. There were eight test words in each block of the visual and auditory conditions and twelve words in each block of the simultaneous condition. Subjects received five blocks per condition in each of the simple and choice RT tasks (15 blocks, 140 trials er task). Each part of the study was presented separately with all subjects completing the simple reaction time conditions (part one) before the choice reaction time conditions (part two). The order of presentation of visual, auditory, and simultaneous blocks of words was randomized for each subject.

For each block of trials the procedure was as follows: a) subjects were told which stimulus condition was to be presented and the relevant category for the block (part two only); b) subjects were given a verbal ready signal; c) the experimenter pressed a key to initiate the block; d) a variable intertrial interval (time between response and onset of next stimulus) of 400, 600, 800 or 1000 ms preceded the stimuli; e) the practice word was presented; f) the subject responded by pressing the appropriate button; g) a variable intertrial interval of 400, 600, 800, or 1000 ms occurred; h) the first test trial occurred; i) the remaining trials were presented at intertrial intervals ranging from 400 to 1000 ms.

RESULTS

The median RT for each condition was calculated for each subject, and these were averaged. Figure 1 shows the averaged median RTs in the various conditions of both tasks. Simple RT was much faster than choice RT (F (1,19)=668.20, p .0001). Dunn's tD test for multiple comparisons was employed to determine whether there were significant differences between all of the various means. All reported differences were significant at the .01

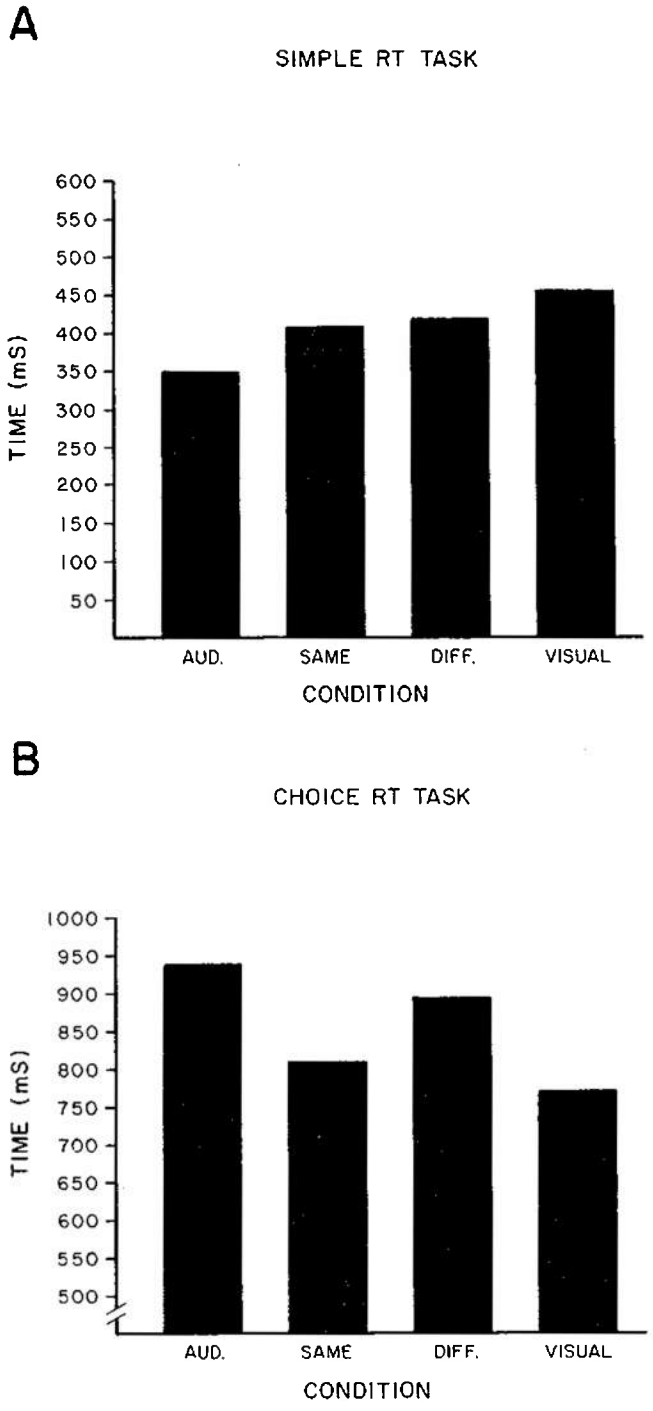

Fig. 1. Mean median reaction times for each condition of the simple (A) and choice (B) reaction time tasks

level. Auditory RT was fastest in the simple task, whereas visual RT was fastest in the choice task. In the simple task RTs under the simultaneous conditions were similar to each other and to visual RT, and all three were slower than auditory RT. In other words, rather than bimodal facilitation, it appeared that the visual stimulus interfered with simple reaction time to the auditory stimulus. In the choice task, subjects processed a visual word faster than an auditory word. When the same word appeared in both modalities performance was similar to the visual RT. When different words were presented in the two modalities performance was similar to the auditory RT.

Figure 2 shows the averaged median choice RTs for the three conditions when the subjects had to relate the words to a category. Once again, Dunn's tD test was used to analyze for differences between means, and reported differences were significant at the .01 level. Visual RT was always fastest, and RT was faster to related words than unrelated words. When the words were related to a category, auditory and simultaneous RT did not differ; when the words were not related to a category, simultaneous RT was faster than auditory RT. Within the simultaneous condition choice RTs were faster to related than unrelated words, and faster when pairs of words were the same than when they were different. Therefore, when redundant information was presented in two modalities simultaneously and pertained to a single positive response, performance was not significantly different from the best single modality. However, when bimodal information was conflicting, and not related to a specific category, performance was hampered.

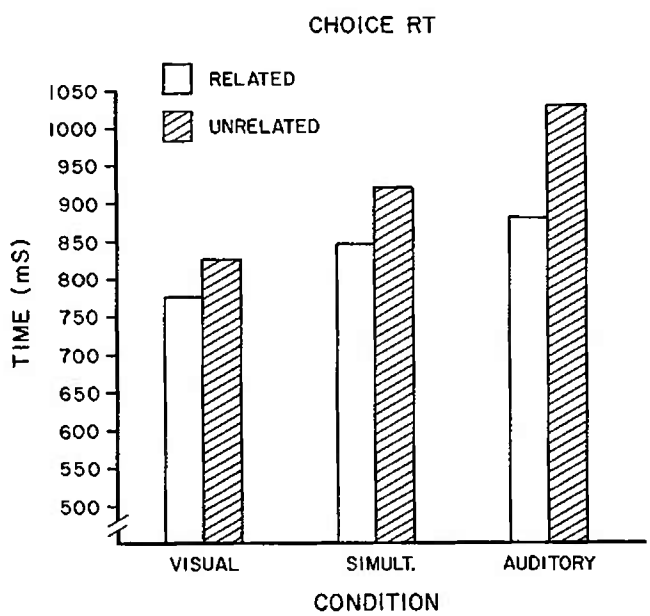

Fig. 2. Mean choice reaction times for words related and unrelated to a category when presented in visual, auditory, or simultaneous conditions

DISCUSSION

As has been reported before (13,14,17,18) performance improved when the information presented together in two modalities was identical or resulted in the same response. Performance was worse when the stimuli were different and indicated conflicting responses (12,14,17,18). A consistent finding of studies which have examined bimodal conditions has been that RT to a simple visual stimulus is facilitated when an accessory auditory stimulus is presented simultaneously or within close temporal proximity with the visual stimulus (6-8,19-22). However, the results have been less clear when auditory stimuli were the primary stimuli and visual stimuli were accessories (6,8,22). The general pattern appears that RT to the slower of the unisensory modes of presentation has been facilitated by bimodal presentations. Little or no facilitation has been found relative to the faster mode of presentation. This finding is not consistent with Nickerson's energy summation model (9).

Which mode was faster or slower depended upon whether a simple or choice RT task was employed. These results are in agreement with the findings of Kobus et al. (16) who found that whether or not performance in a sonar detection task improved depended on the requirements of the task. The pattern of results concerning RT to the various modes of presentation in the choice RT task may be accounted for by the temporal characteristics associated with presenting visual and auditory words, since subjects were able to read words more quickly than they could be spoken.

The present results of this undirected attention study are fairly consistent with those of previous directed attention studies, at stimulus properties in a task can be differentially sampled in both modalities, that more than one set of information can be processed into memory at the same time, and that redundant stimuli affect performance quite differently than conflicting stimuli (11,23). Redundant meaningful information in multiple modalities can improve performance on some taskss. Therefore, it is important to analyze each sonar task to determine whether multiple sources of information help or hinder performance. The superiority of any particular modality depends on whether or not it brings attention to those properties of the stimuli demanded by the task. Future research will need to investigate the various types of stimuli to which sonarmen are exposed and to determine how these interacting stimuli are processed. Whether facilitation or interference occurs seems to depend upon the task requirements, response demands, complexity of the stimuli, and the compatibility between the attended modality and the relevance of the information presented to it.

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The effects of presenting words either visually, aurally, or in both modalities at once on simple and choice reaction time were examined when the words were either related or unrelated to a give category. Simple RT was faster than choice RT, and RT to related words was faster than to unrelated words. Presenting words visually and aurally at the same time did not improve simple RT, but it did improve choice RT when the same word appeared in both modalities. Words that were not identical and not related to a given category

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